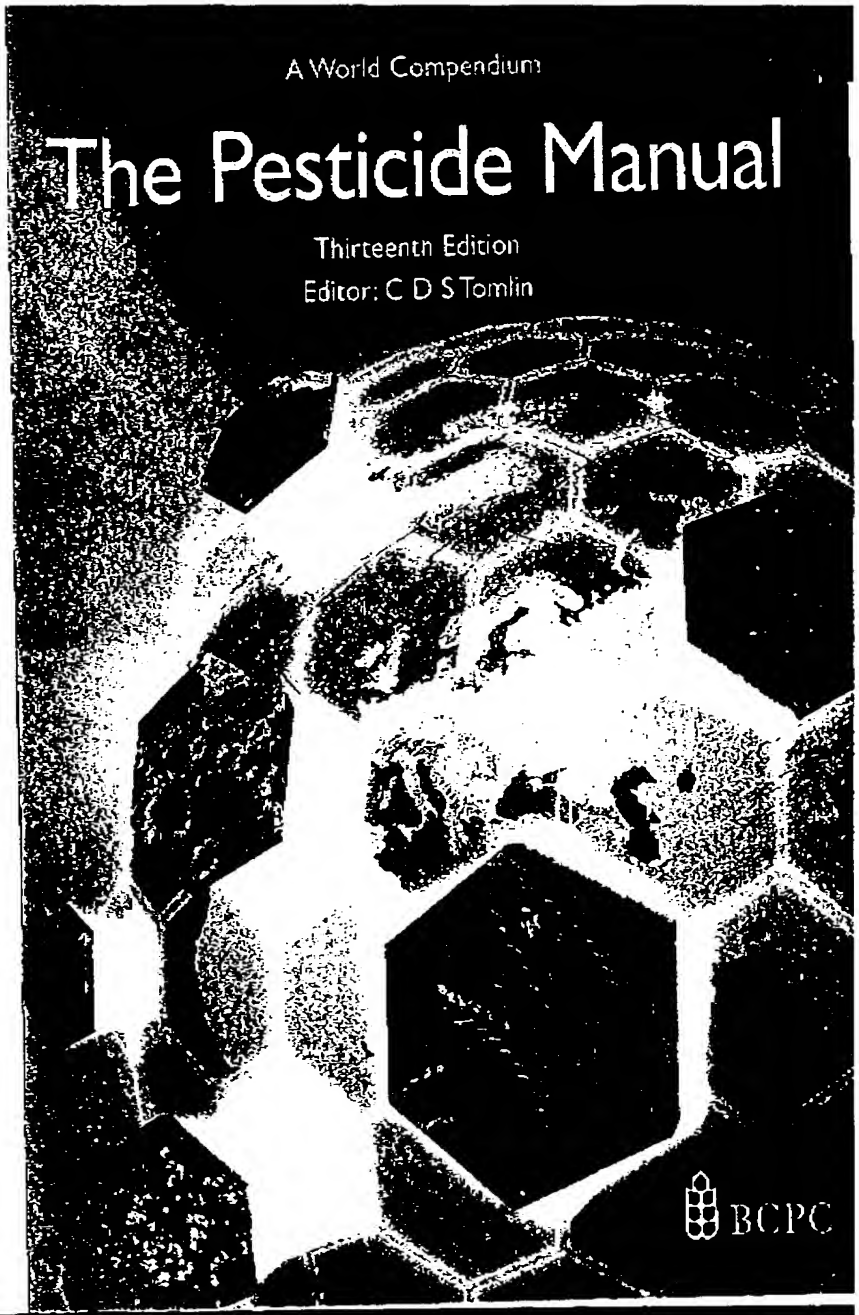
A World Compendium

The Pesticide Manual

Thirteenth Edition

Editor: C D S Tomlin



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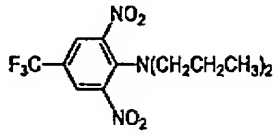
ENVIRONMENTAL FATE: **Animals** Triflumuron labelled in the 2-chlorobenzoyl moiety was metabolised in rats by hydrolytic cleavage, forming metabolites which contained only the 2-chlorophenyl ring and were partly hydroxylated and conjugated. Correspondingly, in experiments with labelling in the 4-trifluoromethoxyphenyl group, metabolites were found which contained only the 4-trifluoromethoxyphenyl ring, partly in hydroxylated form. **Plants** Following spray application to apples, soya beans and potatoes, triflumuron is only slightly metabolised; metabolites were the same as those formed in animals. For residue analyses, it is sufficient to determine the parent compound in the harvested crops. **Soil/Environment Degradation:** In laboratory tests, triflumuron was moderately quickly degraded in the soil; degradation in the field was more rapid by a factor of 3–5. Repeated applications over 3 years to soil without vegetation did not result in any accumulation in the soil. In practice-relevant applications in forests, the concentrations of residues found in the soil were very low at all times, and declined below the limit of detection after a few months. **Metabolism:** In soil, 50% of applied triflumuron labelled in the 2-chlorobenzoyl moiety was degraded to CO_2 within 112 days and c. 20% of the radioactivity was bound to the soil. When using triflumuron labelled in the 4-trifluoromethoxyphenyl moiety, the compound was mineralised more slowly, while the percentage of bound residues was markedly increased. Metabolism was mainly induced by microbes, and resulted in metabolites which contained just one of the two rings in each case.

836 trifluralin *Herbicide*

HRAC K_1 **WSSA 3; dinitroaniline**



NOMENCLATURE: **Common name** trifluralin (BSI, E-ISO, ANSI, WSSA, JMAF); trifluraline ((*f*) F-ISO)
IUPAC name α,α,α-trifluoro-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine
Chemical Abstracts name 2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl)benzenamine
CAS RN *[1582-09-8]* **EC no.** 216-428-8 **Development codes** L-36 352 (DowElanco); EL-152 (Lilly)

PHYSICAL CHEMISTRY: **Mol. wt.** 335.3 **M.f.** $C_{13}H_{16}F_3N_3O_4$ **Form** Yellow-orange crystals. **M.p.** 48.5–49°C; (tech., 43–47.5°C) **B.p.** 96–97°C/24 Pa **V.p.** 6.1 mPa (25°C) (EEC A4) K_{ow} log*P* = 4.83 (20°C) (EEC A8) **Henry** 15 Pa m^3 mol^{-1} (calc.) **S.g./density** 1.36 (22°C) (EEC A3) **Solubility** in water 0.184 (pH 5), 0.221 (pH 7), 0.189 (pH 9) (all in mg/l) (EEC A6); tech. 0.343 (pH 5), 0.395 (pH 7), 0.383 (pH 9) (all in mg/l) (EEC A6). In acetone, chloroform, acetonitrile, toluene, ethyl acetate >1000, methanol 33–40, hexane 50–67 (all in g/l, 25°C). **Stability** Stable at 52°C (highest storage temperature tested). Stable to hydrolysis at pH 3, 6 and 9 (52°C). Decomposed by u.v. irradiation (E. Leitis & D. G. Crosby, *J. Agric. Food Chem.*, 1974, 22, 842). **F.p.** 151°C (closed cup); tech. 153°C (open cup) (both Pensky-Martens)

COMMERCIALISATION: **History** Herbicide reported by E. F. Alder *et al.* (*Proc. North Cent. Weed Control Conf.*, 1960, p. 23). Introduced in USA (1961) by Eli Lilly & Co. (agrochemical interests now Dow AgroSciences). **Patents** US 3257190 **Manufacturers** Agrochem; Atanor; Budapest Chemical; Dintec; Drexel; Makhteshim-Agan; Milenia; Nortox; Nufarm Ltd; Oxon; Q.E.A.C.A.; Westrade.

APPLICATIONS: **Biochemistry** Microtubule assembly inhibition. **Mode of action** Selective soil-herbicide, which acts by entering the seedling in the hypocotyl region. Also inhibits root development. **Uses** Pre-emergence control of many annual grasses and broad-leaved weeds in brassicas, beans, peas, carrots, parsnips, lettuce, capsicums, tomatoes, artichokes, onions, garlic, vines, strawberries, raspberries, citrus fruit, oilseed rape, peanuts, soya beans, sunflowers, safflowers, ornamentals, cotton, sugar beet, sugar cane, and in forestry. Used with linuron or isoproturon for control of annual grasses and broad-leaved weeds in winter cereals. Normally applied pre-planting with soil incorporation, at 0.5–1.0 kg/ha, but post-planting application is also possible for some crops. **Formulation types** EC; GR. **Selected products** 'Treflan' (Dow AgroSciences); 'Trifsan' (Dow AgroSciences); 'Effurin' (Efthymiadis); 'Herbiflurin' (Vapco); 'Ipersan' (Q.E.A.C.A.); 'Olitref' (Budapest Chemical); 'Premerlin' (Milenia); 'Sinfluran' (Westrade); 'Tri-4' (BASF); 'Trifluran' (Cequisa); 'Trifurex' (Makhteshim-Agan); 'Trigard' (FCC); 'Trilin' (Griffin); 'Triplen' (Sipcam); 'Zeltoxone' (Syngenta Spain); **mixtures** 'Team' (+ benfluralin) (Dow AgroSciences); 'Commence' (+ clomazone) (FMC); 'Cotolina' (+ fluometuron) (Aragro).

ANALYSIS: Product analysis by glc with FID (*CIPAC Handbook*, 1998, H, 292; *AOAC Methods*, 17th Ed., 973.14) or by u.v. spectrometry (*ibid.*, 973.13; *CIPAC Handbook*, *loc. cit.*). Residues determined by glc with ECD (J. B. Tepe & R. E. Scroggs, *Anal. Methods Pestic. Plant Growth Regul. Food Addit.*, 1967, 5, 527; *Anal. Methods Pestic. Plant Growth Regul.*, 1972, 6, 703). In drinking water by glc with ECD (*AOAC Methods*, 17th Ed., 990.06). Details from Dow AgroSciences.

MAMMALIAN TOXICOLOGY: IARC ref. 53; class 3 Oral Acute oral LD_{50} for rats >5000 mg/kg. Skin and eye Acute percutaneous LD_{50} for rabbits >5000 mg/kg. Non-irritating to skin; slightly irritating to eyes (rabbits). Inhalation LC_{50} (4 h) for rats >4.8 mg/l. NOEL In 2 y feeding trials in rats, the only effect at the low dose of 813 mg/kg in diet was the formation of renal calculi. This has been shown to be reversible in a 90 d study in dogs, and a NOEL established at 2.4 mg/kg daily. NOEL In mice was 73 mg/kg daily. ADI 0.024 mg/kg. Water GV 20 µg/l (TDI 7.5 µg/kg b.w.). Toxicity class WHO (a.i.) U; EPA (formulation) III, IV
EC classification Material containing <0.5 ppm N-nitrosodipropylamine is Xi; R36| R43| N; R50, R53

ECOTOXICOLOGY: Birds Acute oral LD_{50} for bobwhite quail >2000 mg/kg. Dietary LC_{50} (5 d) for bobwhite quail and mallard ducks >5000 mg/kg. Fish LC_{50} (96 h) for young rainbow trout 0.088, young bluegill sunfish 0.089 mg/l. Daphnia LC_{50} (48 h) 0.245 mg/l; NOEC (21 d) 0.051 mg/l. Algae EC_{50} (7 d) for *Selenastrum capricornutum* 12.2 mg/l; NOEC 5.37 mg/l. Other aquatic spp. LD_{50} (96 h) for grass shrimps (*Palaemonetes* sp.) 0.64 mg/l. Bees LD_{50} (oral and contact) >100 µg/bee. Worms LC_{50} (14 d) >1000 mg/kg dry soil; NOEC (reduced bodyweight) <171 mg/kg.

ENVIRONMENTAL FATE: **Animals** Degradation in animals is as for soil (J. L. Emmerson & R. C. Anderson, *Toxicol. Appl. Pharmacol.*, 1966, 9, 84–97). Following oral administration, c. 70% is eliminated in the urine and 15% in the faeces within 72 hours. **Plants** Degradation in plants is as for soil. **Soil/Environment** Adsorbed by the soil, and is extremely resistant to leaching. Little lateral movement in the soil. Metabolism involves dealkylation of the amino group, reduction of the nitro group to an amino group, partial oxidation of the trifluoromethyl group to a carboxy group, and subsequent degradation to smaller fragments (T. Golab *et al.*, *J. Agric. Food Chem.*, 1979, 27, 163); DT_{50} 57–126 d. Duration of residual activity in soil is 6–8 mo. In laboratory studies, degradation was more rapid under anaerobic conditions, e.g. for loam soil, DT_{50} (anaerobic) 25–59 d, DT_{50} (aerobic) 116–201 d. Soil photolysis DT_{50} 41 d; aqueous photolysis DT_{50} 0.8 h.

flamprop-M-isopropyl
Composition Tech. grade is >96% pure. Mol. wt. 363.8 M.f. $C_{19}H_{19}ClFNO_3$ Form White crystals; (tech., off-white crystals). M.p. 72.5–74.5 °C; (tech., 70–71 °C) V.p. 8.5×10^{-2} mPa (25 °C) K_{ow} logP = 3.69 S.g./density 1315 kg/m^3 Solubility In water 12 mg/l (20 °C). In acetone 1560, cyclohexanone 677, ethanol 147, hexane 16, xylene c. 500 (all in g/l, 20 °C). Stability Stable to light and to heat, and at pH 2–8; DT_{50} (pH 7) 9140 d. Hydrolysed at pH >8 to flamprop-M and isopropanol. F.p. Non-flammable

flamprop-M-methyl
Composition Tech. grade is >96% pure. Mol. wt. 335.8 M.f. $C_{17}H_{15}ClFNO_3$ Form White to light grey crystals. M.p. 84–86 °C; (tech., 81–82 °C) V.p. 1.0 mPa (20 °C) K_{ow} logP = 3.0 S.g./density 1.311 kg/l (22 °C) Solubility In water 0.016 g/l (25 °C). In acetone 406, n-hexane 2.3 (both in g/l, 25 °C). Stability Stable to light and to heat, and at pH 2–7. Hydrolysed in alkaline media (pH >7) to parent acid and methanol.

COMMERCIALISATION: History Herbicidal properties of the isopropyl ester of the D- acid described by R. M. Scott et al. (*Proc. Br. Crop Prot. Conf. - Weeds*, 1976, 2, 723), design discussed by M. A. Venis (*Pestic. Sci.*, 1982, 13, 309) and development by D. Jordan (Spon, 1977, 20, 21). Introduced by Shell Research Ltd (now BASF AG). Patents GB 1437711; GB 1563201 Manufacturers BASF.

APPLICATIONS: Biochemistry Fatty acid synthesis inhibitor. Inhibits cell elongation and cell division, and hence inhibits plant growth. Selectivity depends on differential rates of hydrolysis to the free acid. In tolerant plants, the acid is further de-toxified by formation of conjugates. Mode of action Flamprop-M-isopropyl and -M-methyl are selective systemic herbicides, absorbed by the leaves. Undergo hydrolysis to flamprop-M, which is the herbicidally active compound; in sensitive species, this is transported to meristems.

flamprop-M-isopropyl
Uses Post-emergence control of wild oats (*Avena* spp.) in barley and wheat, including those undersown with clover or ryegrass. Also controls *Alopecurus myosuroides* and *Arrhenatherum elatius*. Phytotoxicity Some varieties of wheat and barley may be injured. Formulation types EC. Compatibility Antagonism with broad-leaved herbicides can be expected. Selected products 'Suffix BW' (BASF).

flamprop-M-methyl
Uses Post-emergence control of wild oats (*Avena* spp.) in wheat, including crops undersown with clover or grass. Also controls *Alopecurus myosuroides*. Phytotoxicity Non-phytotoxic to all spring and winter varieties of wheat. Formulation types EC. Compatibility Miscible with fungicides, chlormequat chloride and foliar nutrients. If applied together with phenoxy herbicides, the activity of flamprop-M-methyl may be reduced. Selected products 'Mataven L' (BASF).

ANALYSIS: Product analysis for esters is by optical rotation and glc. Residues determined by glc with ECD. Details available from BASF.

MAMMALIAN TOXICOLOGY: *flamprop-M*
Toxicity class WHO (a.i.) U

flamprop-M-isopropyl
Oral Acute oral LD_{50} for rats and mice >4000 mg/kg. Skin and eye Acute percutaneous LD_{50} for rats >1600 mg/kg. Not a skin or eye irritant. Inhalation No effect (rats). NOEL In 90 d feeding trials, rats receiving 50 mg/kg diet and dogs receiving 30 mg/kg diet showed no ill-effects. Other Acute i.p. LD_{50} for rats >1200 mg/kg.

flamprop-M-methyl
Oral Acute oral LD_{50} for rats 1210, mice 720 mg/kg. Skin and eye Acute percutaneous LD_{50} for rats >1800 mg/kg (as EC formulation). Non-irritating to skin and eyes. Non-sensitising to skin. Inhalation No effect (rats). NOEL In 90 d feeding trials, rats receiving 2.5 mg/kg daily and dogs receiving 0.5 mg/kg daily showed no ill-effects. Other Acute i.p. LD_{50} for rats 350–500 mg/kg.

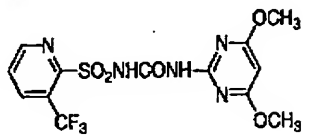
ECOTOXICOLOGY: *flamprop-M-isopropyl*
Birds Acute oral LD_{50} for domestic fowl >2000 mg/kg. Fish LC_{50} (96 h) for rainbow trout 2.4 mg/l. Daphnia Slightly to moderately toxic. Algae EC_{50} (96 h) 6.8 mg/l. Other aquatic spp. Moderately toxic to freshwater and marine crustacea. Bees Non-toxic to bees. Worms Non-toxic. Other beneficial spp. Non-toxic to soil arthropods.

flamprop-M-methyl
Birds Acute oral LD_{50} for bobwhite quail 4640, pheasants, mallard ducks, domestic fowl, partridges, pigeons all >1000 mg/kg. Fish LC_{50} (96 h) for rainbow trout 4.0 mg/l. Daphnia Slightly to moderately toxic. Algae EC_{50} (96 h) 5.1 mg/l. Other aquatic spp. Moderately toxic to freshwater and marine crustacea. Bees Non-toxic to bees. Worms Non-toxic. Other beneficial spp. Non-toxic to soil arthropods.

ENVIRONMENTAL FATE: Animals In mammals, following oral administration of flamprop-M-methyl or flamprop-M-isopropyl, complete metabolism and excretion occurs within 4 days. Plants In plants, flamprop-M-methyl and flamprop-M-isopropyl are hydrolysed to the biologically-active flamprop acid, which then undergoes conversion to a biologically-inactive conjugate. Soil/Environment The major soil degradate from both esters is flamprop free acid.

356 flazasulfuron *Herbicide*

HRAC B WSSA 2; sulfonylurea

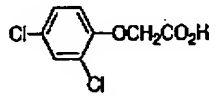


NOMENCLATURE: Common name flazasulfuron (BSI, draft E-ISO)
IUPAC name 1-(4,6-dimethoxypyrimidin-2-yl)-3-(3-trifluoromethyl-2-pyridylsulfonyl)urea
Chemical Abstracts name *N*-[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]-3-(trifluoromethyl)-2-pyridinesulfonamide
CAS RN *[104040-78-0]* Development codes SL-160 (Ishihara Sangyo)

PHYSICAL CHEMISTRY: Mol. wt. 407.3 M.f. $C_{13}H_{12}F_3N_5O_5S$ Form Odourless, white crystalline powder. M.p. 180 °C (purity 99.7%) V.p. <0.013 mPa (25 °C, 35 °C and 45 °C) K_{ow} logP = 1.30 (pH 5); -0.06 (pH 7) Henry $<2.58 \times 10^{-6}$ Pa m^3 mol^{-1} S.g./density 1.606 (20 °C) Solubility In water 2.1 g/l (pH 7, 25 °C). In octanol 0.2, methanol 4.2, acetone 22.7, toluene 0.56, acetonitrile 8.7 (all in g/l, 25 °C); in hexane 0.5 mg/l (25 °C). Stability DT_{50} In water 17.4 h (pH 4); 16.6 d (pH 7); 13.1 d (pH 9) (all 22 °C) pKa 4.37 (20 °C) F.p. Non-flammable

211 2,4-D *Herbicide*

HRAC O WSSA 4; phenoxycarboxylic acid



NOMENCLATURE *2,4-D*
Common name 2,4-D (BSI, E-ISO, (m) F-ISO, WSSA); 2,4-PA (JMAF)
IUPAC name (2,4-dichlorophenoxy)acetic acid
Chemical Abstracts name (2,4-dichlorophenoxy)acetic acid
CAS RN [94-75-7] EC no. 202-361-1 Development codes L208 (Marks)

2,4-D-butotyl
IUPAC name 2-butoxyethyl (2,4-dichlorophenoxy)acetate
CAS RN [1929-73-3] EC no. 217-680-1

2,4-D-butyl
IUPAC name butyl (2,4-dichlorophenoxy)acetate
CAS RN [94-80-4] EC no. 202-364-8

2,4-D-dimethylammonium
IUPAC name dimethylammonium (2,4-dichlorophenoxy)acetate
CAS RN [2008-39-1] EC no. 217-915-8

2,4-D-diolamine (2,4-D-diethanolamine)
IUPAC name bis(2-hydroxyethyl)ammonium (2,4-dichlorophenoxy)acetate
CAS RN [5742-19-8] EC no. 227-256-8

2,4-D-ethyl
IUPAC name ethyl (2,4-dichlorophenoxy)acetate

2,4-D-2-ethylhexyl
IUPAC name 2-ethylhexyl (2,4-dichlorophenoxy)acetate
CAS RN [1928-43-4] EC no. 217-673-3 Development codes N208 (Marks)

2,4-D-isobutyl
IUPAC name 2-methylpropyl (2,4-dichlorophenoxy)acetate
CAS RN [1713-15-1] EC no. 216-992-5

2,4-D-isoctyl
IUPAC name octyl (2,4-dichlorophenoxy)acetate (mixed octyl isomers)
CAS RN [25168-26-7], formerly [1280-20-2] EC no. 246-704-3

2,4-D-isopropyl
IUPAC name isopropyl (2,4-dichlorophenoxy)acetate
CAS RN [94-11-1] EC no. 202-305-6

2,4-D-sodium
IUPAC name sodium (2,4-dichlorophenoxy)acetate
CAS RN [2702-72-9] EC no. 220-290-4

2,4-D-trolamine (2,4-D-triethanolamine)
IUPAC name tris(2-hydroxyethyl)ammonium (2,4-dichlorophenoxy)acetate
CAS RN [2569-01-9] EC no. 219-911-1

PHYSICAL CHEMISTRY: *2,4-D*
Composition Tech. is ≥96% pure. Mol. wt. 221.0 M.f. $C_8H_6Cl_2O_3$ Form Colourless powder, with a slight phenolic odour. M.p. 140.5°C V.p. 1.86×10^{-2} mPa (25°C) (OECD 104) K_{ow} logP = 2.58–2.83 (pH 1), 0.04–0.33 (pH 5) Henry 1.32×10^{-5} Pa m^3 mol^{-1} (calc.) S.g./density 1.508 (20°C) Solubility in water 311 (pH 1), 20 031 (pH 5), 23 180 (pH 7), 34 196 (pH 9) (all in mg/l, 25°C). In ethanol 1250, diethyl ether 243, heptane 1.1, toluene 6.7, xylene 5.8 (all in g/kg, 20°C); in octanol 120 g/l (25°C). Insoluble in petroleum oils. Mono-n-butylamine salt: in water 18 g/l (30°C). Stability 2,4-D is a strong acid, and forms water-soluble salts with alkali metals and amines. Hard water leads to precipitation of the calcium and magnesium salts, but a sequestering agent is included in formulations to prevent this. Photolytic DT_{50} (simulated sunlight) 7.5 d. pKa 2.73

2,4-D-butotyl
Mol. wt. 321.2 M.f. $C_{14}H_{18}Cl_2O_4$

2,4-D-butyl
Mol. wt. 277.1 M.f. $C_{12}H_{14}Cl_2O_3$

2,4-D-dimethylammonium
Mol. wt. 266.1 M.f. $C_{10}H_{13}Cl_2NO_3$ M.p. decomp. c. 120°C Solubility in water 3 kg/l (20°C). Soluble in alcohols and acetone. Insoluble in kerosene and diesel oil.

2,4-D-diolamine (2,4-D-diethanolamine)
Mol. wt. 326.2 M.f. $C_{12}H_{17}Cl_2NO_5$

2,4-D-ethyl
Mol. wt. 249.1 M.f. $C_{10}H_{10}Cl_2O_3$

2,4-D-2-ethylhexyl
Composition Isomeric with 2,4-D-isoctyl; sometimes these names are used interchangeably.
Mol. wt. 333.3 M.f. $C_{16}H_{22}Cl_2O_3$ Form Golden yellow, non-viscous liquid, with a sweet, slightly pungent odour. M.p. <–37°C B.p. >300°C (decomp.) V.p. 47.9 mPa (25°C) K_{ow} logP = 5.78 (25°C) Henry 1.8 Pa m^3 mol^{-1} (calc.) S.g./density 1.148 (20°C) Solubility in water 0.086 mg/l (25°C). Miscible with most organic solvents. Stability Hydrolysis DT_{50} <1 h. Stable to light, DT_{50} >100 d. Stable at 54°C. F.p. 171°C (Cleveland open cup)

2,4-D-isobutyl
Mol. wt. 277.1 M.f. $C_{12}H_{14}Cl_2O_3$

2,4-D-isoctyl
Composition Isomeric with 2,4-D-2-ethylhexyl; sometimes these names are used interchangeably.
Mol. wt. 333.3 M.f. $C_{16}H_{22}Cl_2O_3$ Form Yellowish-brown liquid, with a phenolic odour. B.p. 317°C S.g./density 1.14–1.17 g/ml (20°C) Solubility in water 10 mg/l. F.p. 171°C

2,4-D-isopropyl
Mol. wt. 263.1 M.f. $C_{11}H_{12}Cl_2O_3$ Form Colourless liquid. M.p. 5–10°C and 20–25°C (two forms) B.p. 130°C/1 mmHg V.p. 1.4 Pa (25°C) Solubility Practically insoluble in water. Soluble in alcohols and most oils.

2,4-D-sodium
Mol. wt. 243.0 M.f. $C_8H_5Cl_2NaO_3$ Solubility in water 18 g/l (20°C).